

Chapter 4 – Sampling Design

Note: This chapter is not due until Phase 3 in December 2005, yet a scientifically-valid sampling design requires months of work and we have made significant progress. The following briefly summarizes the Network's progress towards designing an overall sampling framework. The sampling framework will be completed in September 2005.

INTRODUCTION

The development of a defensible sampling framework and detailed sampling protocols requires expertise in several disciplines including various biota, remote sensing, statistics, and monitoring theory. Further, a viable, long-term monitoring program requires partnering with federal and state agencies, universities, and other science institutions. The Great Lakes Inventory and Monitoring Network has contracted with the University of Minnesota's Natural Resource Research Institute (NRRI) and five other institutions to design a sampling scheme and the first set of protocols.

Objectives

The Sampling Design and Protocol Development (SDPD) project has four objectives:

1. Complete sampling protocols for the following five high-ranking Vital Signs:
 - a. Water quality for stream systems
 - b. Water quality for lake systems
 - c. Land use/landscape change
 - d. Terrestrial vegetation
 - e. Amphibians
2. Develop a sampling framework to facilitate the use of common or closely connected sampling sites or areas, with the intention of increasing efficiency, statistical rigor, and opportunities to provide 'weight of evidence' data to assess ecosystem change;
3. Develop the underlying architecture of a data management system that will increase the efficiency and reliability of collecting data in the field, facilitate the examination and summary of the data by end users, and maximize the ability to do synthetic, integrative analyses in the future;
4. Submit one or more scientific papers to *Ecological Applications* or other highly regarded peer reviewed journals to be agreed upon by the Network coordinator and other authors. The publication(s) will document the management and ecological significance of key indicators, the scientific rationale behind the sampling framework that will be used by the Network, and if applicable, summary protocols that will be used for long-term monitoring.

Approach

The development of monitoring protocols for as many as 48 Vital Signs in over one million acres across nine parks in four states is a daunting task. It is critical that the Network collapse this complex problem into an initial subset of high ranking Vital Signs. For this project we selected five Vital Signs based on high scores, commonality across the Network, and apparent ecological linkages between them. The first step will be to refine monitoring questions and specific objectives for each of the five Vital Signs.

The NPS guidelines for developing an integrated monitoring program encourage co-location of sampling (Fancy 2004). Protocols developed in this project will be nested, to the extent possible, within a larger sampling framework, similar to the Great Lakes Environmental Indicators project (Danz et al. *in press*). Thus we can assess the association between different components and how they respond to a similar set of stressors (e.g., as land use changes, does water quality, vegetation and amphibian communities also change?). It also allows for interpretation based on multiple lines of evidence. Co-location of sampling effort, however, raises issues of logistics and statistical integrity that need to be addressed by the collaborators and staff at the nine parks.

The spatial extent at which the five Vital Signs respond to environmental stress ranges from the landscape scale (land use, vegetative cover) to finer scales (water quality, amphibians). Although one of our primary objectives is to link sampling sites for increased efficiency, we anticipate the problem of multiple scales will present considerable problems. Thus our selection of these five protocols will allow us to address this problem at the onset. Further, by developing the terrestrial vegetation and water quality protocols first, we increase our chances of selecting a matrix of land and water-based sampling sites that will be applicable for other Vital Signs. Finally, these five Vital Signs, given our desire to address scale, are particularly well linked ecologically. That is, land use and vegetative cover directly affect water quality (Karr and Chu 1999) for which amphibians may be excellent indicators (Heyer et al. 1993). This allows us an opportunity to explore cause and effect relationships.